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TECHNICAL REPORT
NATICK/TR-90/041

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THERMOSTABILIZED FOODS IN INSTITUTIONAL-SIZE POUCHES

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19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

The purpose of this project is to determine the feasibility of using institutional-size pouches to package and process shelf stable particulate food products.

Food Innovisions Inc. packaged and processed two particulate type products, Chicken a la King and Beef Stew, in institutional-size retort pouches for shipment to U.S. Army Natick Research, Development and Engineering Center. At the conclusion of this segment of the project, evaluation of this packaging system will be performed at the Natick RD&E Center.

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PREFACE

During the period of September 1987 to July 1988, Chemac Industries, Inc. was awarded a contract to produce and test filled institutional-size pouches under Contract No. DAAK60-87-C-0026. Two subcontractors, Food Innovisions, Inc., of New Orleans, LA, and Exxon Chemical Company of Houston, TX were involved in this effort. The evaluation was made under Natick Project No. FED-87-578.

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The authors and Chemac Industries, Inc., wish to thank the Project Officer, Mr. Peter Burke, and Contracting Officer's Representative, Ms. Diane Wood, both of the Food Engineering Directorate (FED), U.S. Army Natick Research, Development and Engineering Center, for their cooperation, responsiveness and tremendous support for the successful completion of this project.

We would also like to thank Ms. Beverly Hogy, Mr. Leon Cabes, Ms. Lisa Schlesinger and many others at Food Innovisions, Inc., for their sincerity, cooperation and diligence in, first, producing the prototypes and, later, conducting the trial production run.

We would also like to acknowledge invaluable assistance provided by Mr. Jack Spencer and Mr. Larry Locke of Exxon Chemical Company.

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INTRODUCTION

Chemac Industries Inc., was contracted by United States Army Natick Research, Development and Engineering Center to prepare, test, and furnish to the United States Government thermostabilized foods in institutional-size pouches, packed in shipping containers, and made into two unit loads (pallets) of two types of food products. The two different food products were required to be a meat product and a fish or poultry product. Although the two food products were specified to be particulate in nature, the exact formulations were left to the Contractor's discretion but subject to approval by the Contracting Officer.

The prime objective of this project was to produce particulate food products in institutional size pouches for evaluation under military use conditions. Major considerations were required for providing a durable, safe, and economical food product in an institutional size pouch equivalent in capacity to a No. 10 (603 X 700) can. A No. 10 can is 6 3/16" in diameter by 7" in height with a capacity to hold approximately 6.25 - 6.50 lb of food product.

Each pouch was required to contain multiserving quantities of food while taking maximum advantage over a No. 10 can in that the filling of the pouch would be with more solids than liquids.

The filled, sealed, and processed pouches were required to be boxed, at least four per container, in a shipping container conforming to Federal Specification PPP-B-636, V3c and then palletized[1]. Shipping containers were to be palletized and then stretch wrapped in accordance to MIL-L-35078K and MIL-STD-147C,[2,3] respectively. Prior to delivery to the Government, representative samples of pouches in shipping containers were required to pass vibration testing, and drop testing from a height of 18 inches, in accordance with American Society of Testing and Materials (ASTM) Methods D999-75 and D775-61[4,5], respectively.

TECHNICAL APPROACH

The project was divided into several major tasks as follows:

A. Selection of Pouch Material and Pouch Design
B. Design of Shipping Containers
C. Food Product Formulation Development
D. Production of Laboratory Prototypes
E. Trial Production
F. Discussion, Conclusions, and Recommendations

Completion of each task was marked by the submission of findings to the Contracting Officer for evaluation and approval by the Contracting Officers

Representative (COR). This report will describe activities undertaken to successfully complete each task of the project.

A. SELECTION OF POUCH MATERIAL AND POUCH DESIGN

Several major suppliers of packaging materials were contacted regarding material requirements for the institutional-size pouches. The following three candidate film materials were given consideration:

a) Film Specification Number: 3568

Alcan Canada Foils
1891 Eglington Avenue, South
Scarborough, Ontario, Canada
M1L 2L7

b) Film Specification Number: 2673

Lawson Marden Flexible Packaging
(formerly Dow Chemicals Canada)
130 Arrow Road
Weston, Ontario, Canada
M9M 2M2

c) Film Specification Number: Exxtrapak* 590 (E-590)

Exxon Chemical Company
Polymers Group - Americas
P.O. Box 3272
Houston, Texas
77253-3272

The evaluation and selection of candidate films was primarily based upon manufacturers' specifications and technical data. Table 1 outlines manufacturer's specifications for each candidate film.

As a result of previous experience with pouch film material, particularly E-590 type of materials, for another US Army Natick contract (DAAK60-85-C-0043[6]), the material selection process for this project was relatively short. The Lawson Marden material was discounted because of its nonretortability and poor moisture and oxygen barrier properties. The Exxon material was selected over the Alcan material because of its thicker sealant and outer layers. Exxon has reported that the E-590 material exhibits outstanding barrier properties for moisture vapor and oxygen, high impact resistance, excellent burst and seal strength, excellent freeze/thaw stability and resistance to odor/flavor migration.[7]

* Exxtrapak is a registered trademark of Exxon Chemical Company.

Table 1. Manufacturers' Specifications for the Candidate Films for Institutional-Size Pouches.

	Composition*	Retortable	MVTR	Oxygen Permeation
ALCAN #3568	PP 76/AL 18/PS 12	Yes	Negligible	5.6×10^{-5}***
LAWSON #2673	PE 76/AL 09/PS 12	No**	2.8****	9.0***
EXXON E-590	Sealant 101.4/ AL 8.89/PS 23.5	Yes	Negligible	Negligible

* PP = Polypropylene
AL = Aluminum Foil
PE = Polyethylene
PS = Polyester

The numbers associated with each component indicate the thickness (in microns) of each component of the laminate.

** Lawson #2673 material is not retortable but it is hot fillable.

*** $cc/in^2/24$ hr

**** $g/100\ in^2/24$ hr

The E-590 material is fully approved for food use. For further proof of the suitability of E-590 for packaging food, the supplier provided the following Food & Drug Administration (FDA) Conformance Statement:[7]

> "Exxtrapak Quality Packaging Material conforms to the provisions of the 21 CFR 177-1390 High Temperature Laminates regulations for use in direct contact with non-alcoholic foods at temperatures not to exceed 275°F (135°C)."

With the consent of Contracting Officer's Representative (COR), the E-590 material was selected for prototype pouch production. The pouch design recommended by the COR was that of a standard 12" X 15" (30.5 cm X 38.1 cm) four sided pouch with two side seals, one end seal and one end left open for filling and sealing. Previous experience had shown that a pouch of this size was large enough to contain approximately 6.5 lb (2.95 kg) of food product. Figure 1 shows the basic design and appearance of the pouch.

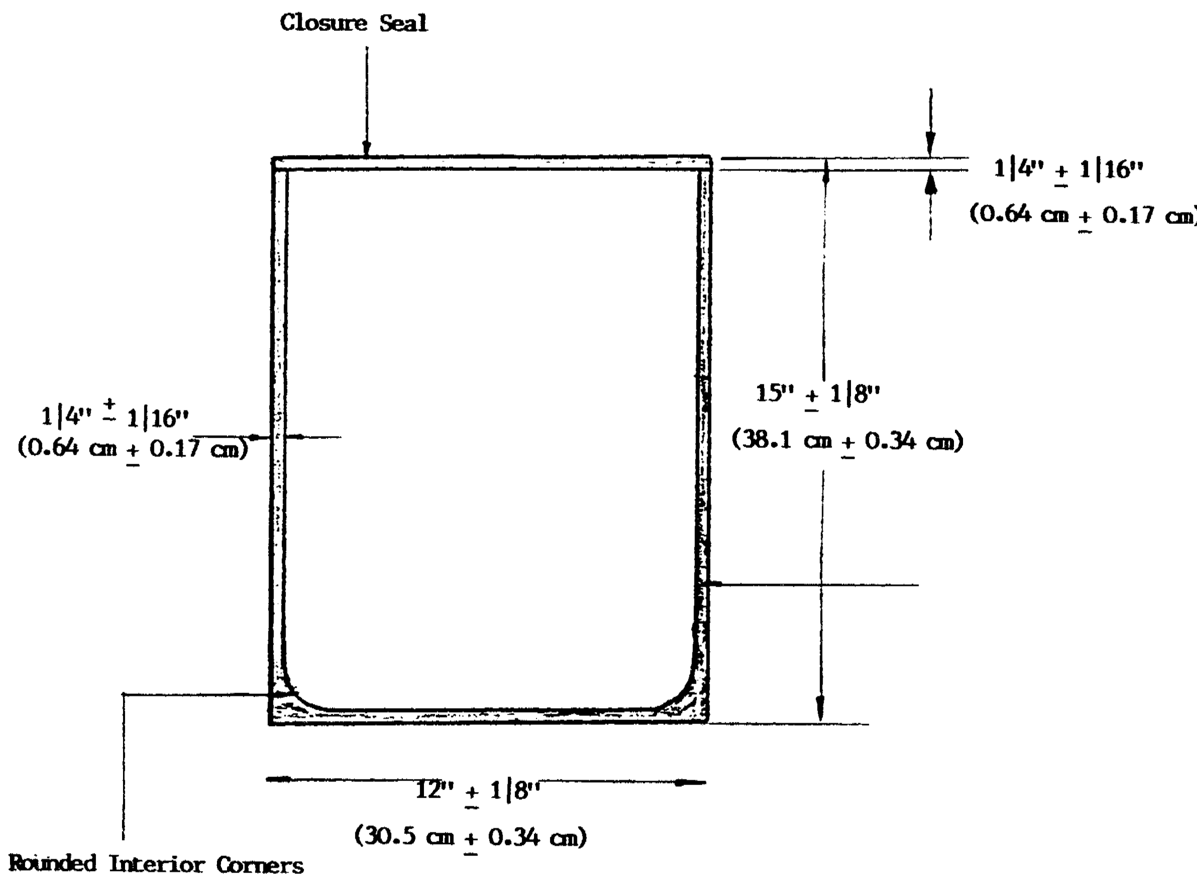


Figure 1. Basic Prototype Design of Institutional Size Retort Pouch

B. DESIGN OF SHIPPING CONTAINERS

The contract stipulated that at least four institutional-size pouches must be packed per shipping container similar in design to containers in commercial use, except the container required for this contract must be made from V3c weather-resistant corrugated fiberboard materials conforming to Federal Specification PPP-B-636J[1].

On COR's advice, the shipping container was designed to contain 6 pouches. The basic design for the shipping container was provided by the COR. The proposed design of the shipping container consisted of a regular slotted (RSC) container with 2" manufacturers joint, with inside dimensions measuring 19-3/8" L X 12-3/4" W X 5-1/2" H (49.2 cm L X 32.4 cm W X 14.0 cm H) with die-cut insert, which, when folded and placed in the container, formed two equal size chambers for placement of pouches. The die-cut insert was necessary to properly confine the pouches in the container. This shipping container concept had previously been evaluated by Natick personnel for similar applications and had been found to be quite acceptable.

Figure 2 illustrates the RSC container and die-cut insert specifications. This figure also demonstrates the correct procedure for folding and placement of insert in the container.

The same shipping container was proposed for both food products. However, it was recognized that 6.5 lb (2.95 kg) of different food products would not necessarily occupy the same space or volume in the shipping container. Therefore, it was proposed that when packing processed pouches in the shipping containers, any vacant space in the container would be filled with fiberboard pads measuring 9-5/8" x 12-1/2" (24.4 cm x 31.8 cm) as illustrated in Figure 2.

The shipping containers were manufactured by Nelson Die-Cutting & Packaging Inc., of Spartanburg, South Carolina. However, prior to manufacturing the shipping containers, approval was sought and received from the COR for the proposed design and procedures for packing pouches in the containers.

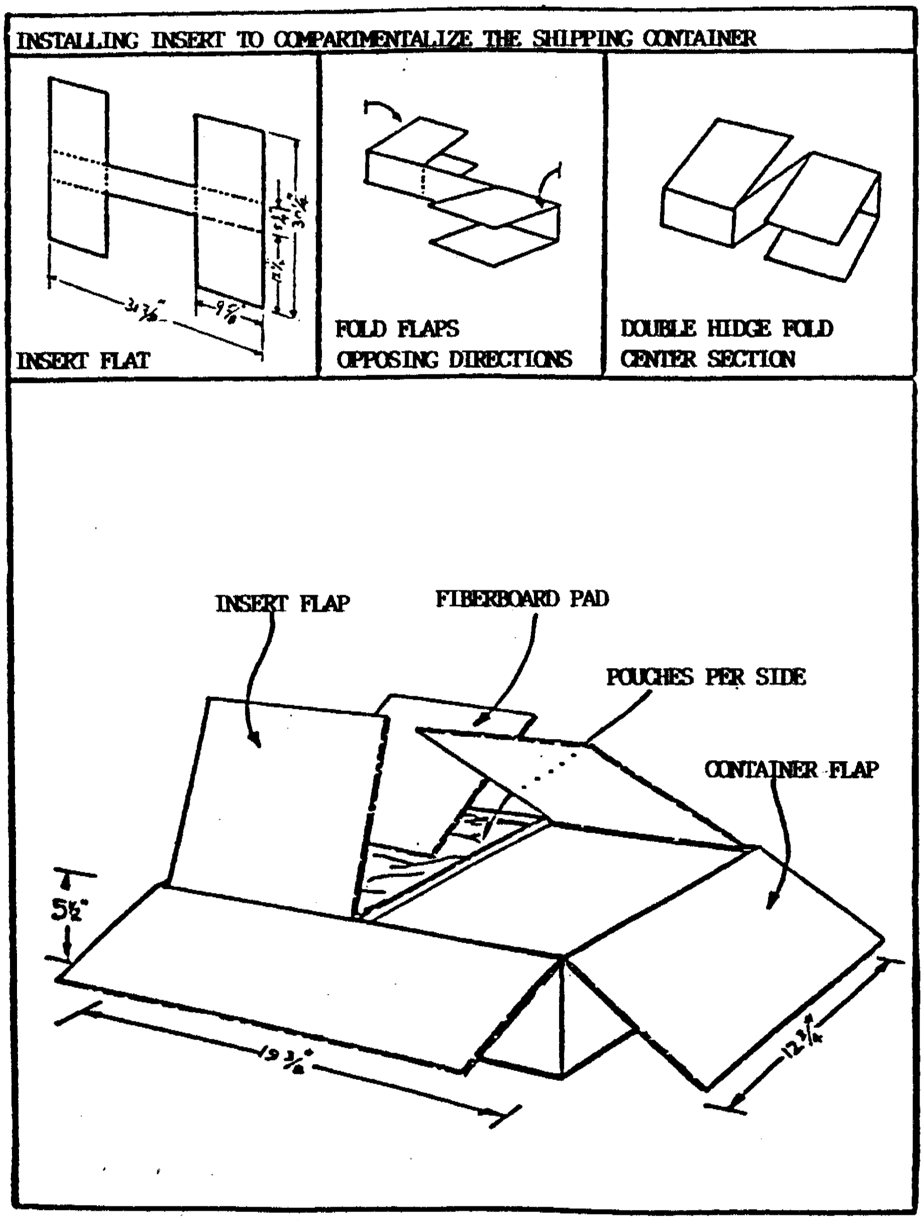


Figure 2. Shipping Container with the Die-Cut Insert and the Fiberboard Pads to completely Immobilize the Pouches. This Figure also demonstrates the correct way to fold the Die-Cut Insert.

C. FOOD PRODUCT FORMULATION DEVELOPMENT

Two different foods were required to be packaged in institutional-size pouches. One of the products was to be a meat entree utilizing large pieces of meat or formed meat, and the other product could be either a fish or poultry entree, utilizing large pieces. The selection, formulation, preparation, and packaging of the food entrees was left to the discretion of the contractor. However, the food entrees selected by the contractor were subject to written approval by the COR prior to any manufacture of the product.

Rather than custom developing formulations for this project, Chemac Industries elected to use previously developed military formulations, such as those used for Meal, Ready to Eat (MRE) programs. The formulations selected were Beef Stew (MIL-B-44059B, Beef Stew, Thermostabilized, Meal, Ready to Eat)[8] and Chicken A La King (MIL-C-44060B, Chicken A La King, Thermostabilized, Meal, Ready to Eat).[9] For this contract, each food product was formulated, prepared, and packaged in accordance with its respective Military Specification.

At the request of the COR, the Chicken A La King formulation was slightly modified to use chicken that had been cooked, and the meat pulled off the carcass, then passed through a screen to remove pieces smaller than 1/4" (0.6 cm).

Refer to Appendix A for detailed descriptions of product formulations, preparation procedures, a list of ingredients, and also a list of ingredient suppliers.

The food product formulation selections were submitted to the COR for approval prior to production of any prototypes. Selection of Beef Stew and Chicken A La King as the two food entrees was approved and permission granted to proceed with the production of prototype pouches.

D. PRODUCTION OF LABORATORY PROTOTYPES

In order to evaluate the food formulations and to determine pouch filling, sealing, and thermal processing conditions, several prototype pouches, containing each type of food product were manufactured in the laboratory. For these trials, several preformed 12" X 15" (30.5 cm X 38.1 cm) pouches were obtained from the supplier. Small batches of each food entree were produced in accordance with the respective Military Specifications. Each pouch was cold filled with 6.5 lb (2.95 kg) of food product, air was manually squeezed out of each pouch, and then each pouch was sealed at 188C (370^{o}F) for 4 seconds. The sealed pouches were heat processed in a laboratory scale retort to commercial sterility of $F_o \geq 6$ minutes. Appendix B provides details of the thermal processing procedures employed.

Several heat processed pouches of each entree were submitted to the COR for evaluation of the packaging concept, product taste, texture, and solids-to-liquid ratio of pouch contents. An evaluation of the prototype pouches by the

COR revealed that, although, the taste, texture, and solids/liquid ratio of both entrees were quite acceptable, the packaging of the pouches required some major improvements. The prototype pouches exhibited many seal failures, primarily due to the very poor seal strengths. The seal strength measurements were typically in the range of 8 to 11 psi (0.6 to 0.8 kg/cm^2) when, ideally, these values should have been >20 psi (>1.4 kg/cm^2). Extensive flex cracking and some delamination of the pouch material was also evident. The residual air content in each pouch was totally unacceptable.

Excessive residual air content of the prototype pouches was singled out as the major contributor to the very poor seal integrity. The expansion of excessive residual air in the pouch during thermal processing would seriously stress the pouch seals. Another factor in the poor condition of the prototypes was the manner in which they were packaged for shipping. The pouches experienced considerable physical abuse while in transit because they were loosely packed in the shipping containers. The loose packaging allowed the pouch contents to slosh back and forth while in transit, thus seriously stressing the seals. This loose packaging may also have contributed to the flex cracking of the pouch material.

Various steps were taken to rectify the problems encountered with the initial set of prototypes. The residual air content of the sealed pouches was minimized [<3.1 cu in (50cc) of air per pouch] by hot-filling (130-150°F or 55-65°C) the pouches and then steam flushing the pouches for approximately 4 seconds immediately before sealing. Then, the pouches were heat-processed in a similar manner as before. The packing of the pouches for shipping was greatly improved by packing six pouches per shipping container specifically designed for large retort pouches (see section B, page 6), and by totally confining the pouches in the container to minimize any movement of the pouch contents and the pouches.

At this point in the project, it was learned that the pouch supplier, Exxon Chemicals Co., produced several subtypes of E-590 pouch material. The very first sample of pouches provided to the COR for evaluation had been designated OX24 variant of E-590. However, the first set of prototype pouches provided to the COR for evaluation were made from PX25A variant of E-590, which compared poorly with OX24. The pouch supplier was reapproached to supply pouches made from OX24 or equivalent material. The second set of prototypes were made from E-590 variant OX24, coded as RX24.

The second set of prototypes submitted to the COR for evaluation revealed great improvement in the seal integrity, residual air content, flex cracking and delamination of the pouch material. Some of the improvement was due to experience gained by the contractor while producing prototypes. Typical seal strength values were in the range of 20 to 22 psi (1.4 to 1.6 kg/cm^2). These pouches, while still packed in the original shipping container, upon arrival at Natick, were subjected to vibration testing for one-half hour (ASTM Method D999-75)[4] and drop testing on five sides from height of 18 inches (45.7 cm) (ASTM Method D775-61)[5]. These results revealed that the shipping container and method of packing afforded the pouches very good protection against rough handling.

Based on the improvements in appearance of pouches, reduction in the level of residual air, improved seal integrity, better packing in shipping containers, and the use of OX24 pouch material, the COR considered the second set of prototypes acceptable and granted permission to proceed with large scale production.

E. TRIAL PRODUCTION

This contract required Chemac Industries, Inc. to deliver a total of four unit loads, (two unit loads of each food entree) to the COR for further evaluation. Chemac Industries subcontracted Food Innovisions, Inc. of New Orleans, Louisiana, to conduct the trial production run to produce the required four unit loads of product. Food Innovisions, Inc. (FII) offered a United States Department of Agriculture (USDA) approved food production facility with in-house USDA inspection service. FII also offered extensive experience and expertise in the production of food products in retortable pouches, albeit, with 5" X 7" (12.7 cm X 17.8 cm) single serve pouches.

FII extracted product formulations for Beef Stew and Chicken A La King from the Military Specifications[8,9]. Production formulations were simply a scale-up of prototype formulations. Due to limited production capacity and labor availability, each product was produced in several small batches.

Each entree was prepared in a steam kettle equipped with an agitator for thorough mixing. See Appendix A for detailed description of product preparation. The prepared product was either packaged into pouches the same day or refrigerated overnight for the following day. The refrigerated product was reheated to (130-150°F (55-65°C) prior to packaging into the pouches.

Approximately 70-80 lb (32-36 kg) portions of cooked product were withdrawn from the kettle into plastic pails and transferred to the pouch filling station. At the filling station 6.5 lb (2.95 kg) of product were weighed out into a plastic jug. The weighed product was then transferred into the pouch.

The filled pouches were heat-sealed on a prototype Fill-Seal Machine developed specifically for large retortable pouches. This machine, a prototype model shown in Figure 3, was provided to FII by Exxon Chemicals Co. This machine utilizes electricity and compressed air, but is manually operated. It is approximately 3 feet (0.9 m) wide, 10 feet (3.0 m) long and approximately 3 feet (0.9 m) high. It can accommodate pouches ranging in sizes 8-12" (20.3-30.5 cm) wide and up to 18" (45.7 cm) long. The machine is equipped for steam flushing prior to pouch sealing. A special jig had to be manufactured for this machine to facilitate better support for the large pouches while being filled and sealed. Refer to Figure 3 for further details of the pouch fill/seal machine.

The fill-seal machine has 5 stages (see Figure 3) for filling and sealing the pouches. At stage 1, a pouch is loaded into the specially manufactured jig. The pouch is held in place by mechanical, finger-like grippers at the top end of both side seals. These grippers can be moved closer together, thus

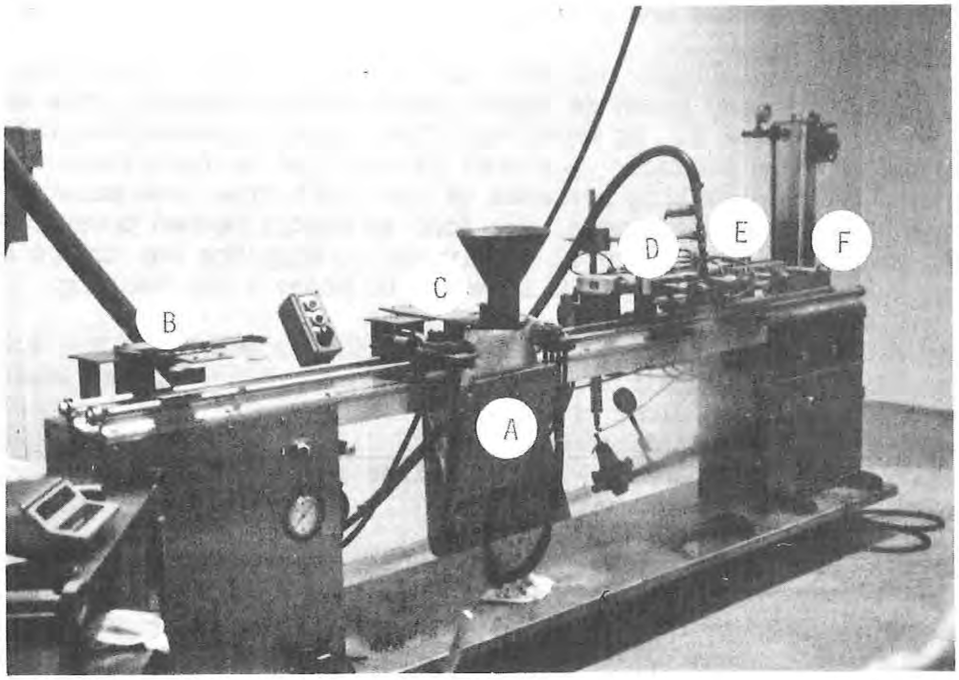


Figure 3. Prototype Model Fill/Seal Machine. The picture depicts the pouch in a special jig at Stage 2, ready for filling via the funnel. Other areas identified on the picture are as follows: A. Specially developed jig to support the pouch; B. Stage 1, Pouch loading; C. Stage 2, Pouch filling zone; D. Stage 3, Pouch sealing zone with two hot horizontal bars and steam flushing outlet; E. Stage 4, Pouch seal cooling bars; F. Stage 5, Pouch removal zone.

enabling the pouch to be opened, or the grippers can be moved further apart to facilitate closing of the pouch. At stage 1, the grippers are close together so that the pouch can be opened for filling.

The entire jig and gripper assembly can be moved side to side on a set of guide rails. Once an empty pouch is loaded into the jig assembly, the entire assembly is moved to stage 2. At this stage the pouch is opened and filled with 6.5 lb (2.95 kg) of food product. A funnel is utilized to facilitate easier filling and also to keep sealing surfaces of the pouch free from moisture and food particles. With a wooden ladle, the food is gently pushed towards the bottom of the pouch to distribute it evenly and to displace any trapped air. After filling the pouch, the assembly is moved to stage 3 for sealing.

At stage 3, the pouch is opened and flushed with steam for 3.5 - 4.0 seconds to minimize residual air in the sealed pouch. After steam flushing, the grippers are moved apart to close the pouch. Two horizontal sealing bars, one on either side of the pouch and heated to 370°F (188°C), are forced together to seal the pouch for two seconds. After sealing the pouch, the entire assembly is moved to stage 4.

Stage 4 is very similar to stage 3 in that it also has two horizontal bars, one on either side of the pouch. However, these bars are not heated. These bars are closed together to cool the seal and remove the irregularities produced by heat stress in that area. After cooling, the pouch assembly is moved to stage 5.

At stage 5, the grippers are opened to release the pouch. The pouch is carefully removed from the jig and the seal examined for wrinkles, trapped food particles, moisture and air. If the seal is satisfactory, the pouch is gently placed into a retort rack for heat processing.

Random samples of sealed pouches were withdrawn, preretort, for determination of residual air and seal burst strength. The residual air in filled and sealed pouches was determined by opening the pouch under water into an inverted water filled 50 ml buret with a funnel attached to the submerged end. The pouch was squeezed, while under water, to force all air into the buret. The amount of residual air in the filled and sealed pouch could then be read directly off the buret scale.

The pouch burst strength was determined with a Regulated Pneumatic Burst Strength Tester. Each random sample of a pouch was tested at minimum of 30 psi (2.1 kg/cm^2) for at least 30 seconds. Table 2 summarizes typical residual air and burst strength values for filled and sealed pouches tested.

Table 2. Typical Residual Air and Burst Strength Values as Determined on Pouches Filled with Beef Stew and Chicken A La King.

Product	Batch Tested	Time Sampled	Residual Air (ml)	Burst Strength (30 psi-30 sec)
Beef Stew	#5 & #6	11:30 am	53	passed
		2:00 pm	78	passed
		4:00 pm	60	passed
		6:00 pm	65	passed
	#7 & #8	10:45 am	62	passed
		12:30 pm	75	passed
		3:00 pm	90	passed
Chicken a La King	#3 & #4	10:45 am	38	passed
		12:45 pm	40	passed
		4:00 pm	36	passed
	#5 & #6	11:30 am	67	passed
		2:00 pm	65	passed
		3:30 pm	70	passed
		5:30 pm	72	passed

Filled and sealed pouches were gently placed into racks for retorting. Each rack measuring 26.5" X 30.0" (67.3 cm X 76.2 cm) was subdivided into four equal size chambers. Each chamber measured 13.25" W X 15" L X 2" H (33.6 cm W 38.1 cm L 5.1 cm H). One filled pouch was placed in each chamber (see Figure 4). Loaded pouch racks were stacked, 13 high, in a retort cart (See Figure 5). Racks stacked in this manner immobilized and confined the pouches to a maximum of 2" (5.1 cm) vertical expansion. Two carts loaded in this manner constituted a retort batch.

In each retort batch, there were three pouches filled with 6.5 lb (2.95 kg) of product and equipped with thermocouples. These pouches were placed in a retort cart on a rack, third from the top. The thermocouples leads from the three pouches were interfaced to a process computer. The process computer monitored heating and cooling of the product in the retort and also calculated the thermal process necessary to attain commercial sterility of the product. Appendix B provides further details of the thermal procedures employed.

Once the pouches had been heat processed, the carts were removed from the retort and allowed to cool and drain. Cooled pouches were gently removed from the racks, dried with paper towels and visually examined for seal integrity, flex cracking and any evidence of leakage or other flaws that may cause the pouches to fail during rigorous handling. Any pouches exhibiting poor seal integrity, excessive flex cracking, evidence of leakage of food, or moisture trapped in the sealed areas were rejected. Each inspected pouch was then labelled (see Figure 6) and gently placed into the shipping container.

A total of six pouches were placed in a shipping container. The flaps of the shipping containers were glued shut, taped and finally labelled (see Figure 7) before being palletized. The palletizing was in accordance with load pattern #5 (See Figure 8) of MIL-STD-147C[3]. Palletized loads were then stretch wrapped with EVA-type stretch film in accordance with Standard MIL-STD-147C[3].

Prior to stretch wrapping the palletized loads, a random sampling, consisting of 5 boxes each of Beef Stew and Chicken A La King, were withdrawn and submitted to the COR for rough handling tests. The 10 boxes were secured on a pallet and shipped via a commercial truck transport to Natick. Upon arrival at Natick, all boxes, of both types of entrees, were subjected to vibration and drop testing in accordance with the American Society for Testing and Materials (ASTM) methods D999-75 and D775-61 respectively [4,5].

Rough handling test results revealed that Chicken A La King was adequately packaged and packed as there was only one leaker, which was due to a flex crack in a corner of the pouch. The situation with Beef Stew was completely different. After rough handling tests, there were 10 leakers and 1 swollen pouch in a sampling of five containers of Beef Stew. The leakers were mainly due to flex cracks distributed randomly on the pouch surfaces. However, there was also one side seal failure and one bottom (pouch manufacturer's) seal failure. The majority of the flex cracks and seal failures were attributed to poor packing of the pouches into the shipping containers. Apparently, six pouches of Beef Stew did not occupy the entire space in the shipping container. There were no fiberboard pads in the shipping containers to immobilize the pouches during transit and rough handling tests. The excess space in the container was sufficient to allow the pouches freedom of movement, particularly during rough handling tests.

Based upon rough handling results and visual examination of the pouches, the COR declared Chicken A La King acceptable and Beef Stew unacceptable for shipment to Natick. The Beef Stew was required to be reexamined and repacked using fiberboard pads to completely immobilize the pouches before it could be shipped to Natick for a second series of rough handling tests.

The entire production of Beef Stew was then repacked with fiberboard pads to totally confine the pouches in the shipping containers. The flaps of the shipping containers were reglued, taped and palletized. The palletized loads were resampled to select containers for rough handling tests. The second set of rough handling tests were conducted at Riviana Foods, Houston, Texas. However, the test methods employed were the same as Natick tests. A copy of the test results from Riviana Foods are included in Appendix C.

The results of a second set of rough handling tests revealed that there were no leakers or seal failures. This fact reinforced the belief that leakers and seal failures in the first set of rough handling tests were primarily due to the lack of padding or poor immobilization of pouches in the shipping containers. As a result of the successful second round of rough handling tests, Beef Stew was declared acceptable for shipping to Natick by the COR.

As required by the contract, four palletized and stretch wrapped unit loads, two each of Beef Stew and Chicken A La King, were stacked two high and loaded on a commercial truck and shipped to the COR for further evaluations.

F. DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

To complete all the requirements of this contract, Chemac Industries selected Exxon packaging material and previously developed product formulations. The Exxon packaging material had shown good promise during evaluation for another somewhat similar application and product formulations had been thoroughly evaluated and were currently in use.

To ensure that both, Beef Stew and Chicken A La King, were produced in a USDA-approved and inspected establishment, Chemac sought a production facility in the United States. The nearest qualified facility willing to manufacture such a small number of pouches (1200-1500 pouches) was Food Innovisions, Inc.

Based in New Orleans, Louisiana, Food Innovisions currently manufactures food entrees in single-serve retort pouches. Much of the work carried out by Food Innovisions is custom manufacturing. Although Food Innovisions possessed considerable experience and expertise with small retort pouches, experience with institutional-size pouches was limited. The lack of experience with the large pouch combined with the relatively new and untested pouch material most certainly led to some complications during the production of filled and sealed pouches.

Food Innovisions had recently acquired a Fill/Seal machine for institutional size pouches. This machine was a prototype model. No individual had been trained to operate the machine. Through intensive on-the-job training, the filling and sealing was mastered fairly quickly.

Exxon provided several prototype variations (i.e., PX, RX and OX) of the chosen, E-590, pouch material. All variations of the E-590 material did not behave equally. Therefore, time and effort was expended to select the most suitable variant of the E-590 material. The OX, and to some degree RX, materials were found to be adequate for this application. All variants coded PX were unacceptable.

For thermoprocessing of the filled and sealed pouches, Food Innovisions assumed that both Beef Stew and Chicken A La King would exhibit convection type heating behavior. Accordingly, the Improved General Method of Ball (1957)[10] was selected for thermal process calculations and evaluation. The observation and evaluation of finished product, as delivered to the COR revealed that Chicken A La King seemed to have received adequate ($F_o > 6$ minutes) thermoprocessing, as evidenced by the absence of swollen pouches.

Beef Stew, however, revealed a totally different picture. There were numerous swollen and leaking pouches in the production lot submitted to the COR. There are several possible explanations for the pouch failures. Most of

Figure 4. Placement of Filled and Sealed Pouches into Retort Rack.

Figure 5. Retort Cart Partially Loaded with Retort Racks.

PRODUCT NAME - BEEF STEW, THERMOSTABILIZED
INGREDIENTS - Cooked beef, potatoes, carrots, green peas, garlic powder, caramel color, soluble celery, black pepper, hydrolyzed vegetable protein, onion powder, sugar, salt, margarine, tomato paste, modified food starch, water.
DATE PROCESSED -
BATCH CODE -
NET WEIGHTS - 6.5 lbs.
ESTABLISHMENT #13048

PACKED BY: FOOD INNOVISIONS, INC.
1417 EDWARDS AVENUE
HARAHAN, LA 70123

TEST PRODUCT ONLY NOT FOR RESALE

PRODUCT NAME - CHICKEN ALA KING, THERMOSTABILIZED
INGREDIENTS - Chicken, chicken broth, modified food starch, dehydrated cream cheese, frozen chicken fat, mushrooms, green peas, powdered vegetable shortening, pimiento's, dehydrated onions, dehydrated celery, salt, freeze dried sweet green pepper, lecithin, white pepper, ground bay leaves, mushroom brine, water.
DATE PROCESSED -
BATCH CODE -
NET WEIGHTS - 6.5 lbs.
ESTABLISHMENT #P13048

PACKED BY: FOOD INNOVISIONS, INC.
1417 EDWARDS AVENUE
HARAHAN, LA 70123

TEST PRODUCT ONLY NOT FOR RESALE

Figure 6. Specimens of Labels Affixed to the Processed Pouches, prior to Packing into Shipping Containers.

CHICKEN A LA KING,
THERMOSTABILIZED
IN INSTITUTIONAL
SIZE POUCHES

6-6.5 LBS. PG
42 LBS., CU 0.8

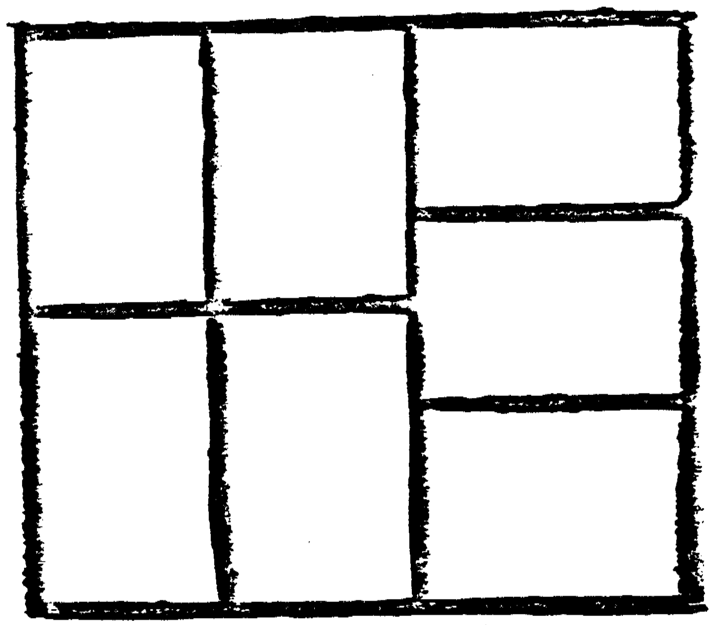
DAAK60-87-C-0026
CHEMAC INDUSTRIES, INC.
11-368 INDUSTRIAL AVE.
KELOWNA, B.C.
CANADA, V1Y 7E8

BEEF STEW,
THERMOSTABILIZED
IN INSTITUTIONAL
SIZE POUCHES

6-6.5 LBS. PG
42 LBS., CU 0.8

DAAK60-87-C-0026
CHEMAC INDUSTRIES, INC.
11-368 INDUSTRIAL AVE.
KELOWNA, B.C.
CANADA, V1Y 7E8

Figure 7. Specimens of Labels Affixed to Shipping Containers.



5

Figure 8. Shipping Containers were Palletized to Conform with Load Pattern #5 of MIL-STD-147C.

the leaks had occurred at bottom or side seals indicating a possible problem with manufacture of preformed pouches. Although attempts were made to minimize residual air in the sealed pouches, it is possible that the side and bottom seals failed due to excessive residual air within the pouch. The swelling of pouches is indicative of contamination by microorganisms. The question is, at what point in the production process did the contamination take place? Significant size and number of pinholes or flex cracks in the pouch surface would allow introduction of microorganisms into the pouch, particularly during the cooling cycle of the retort. Another possible cause for the bacterial growth in the processed pouches may be bacterial survival after thermoprocessing. The thermal process employed for Beef Stew assumed convection heating behavior. It is quite possible that the Beef Stew exhibits conduction heating behavior. If such were the case, then the thermal processing employed could have been totally inadequate to significantly reduce the bacterial population. The heating behavior of Beef Stew and perhaps also Chicken A La King certainly requires closer examination.

Packing the processed pouches in shipping containers revealed another complication. It was learned that it is of paramount importance to completely immobilize or restrain the pouches in the shipping container in order to prevent damage caused by rough handling. Rough handling tests (vibration and drop tests) indicated that packing of Beef Stew into shipping containers requires fiberboard padding to completely fill-up the container and immobilize the pouches. Further trials are necessary to determine the optimum shipping container size and number of fiberboard pads required for both Beef Stew and Chicken A La King.

Rough handling tests demonstrated that properly restrained pouches, packed six per shipping container, will be able to withstand the type of rough handling abuse that will be encountered in the military distribution system.

Despite the difficulties encountered in the production trial run of Beef Stew and Chicken A La King, the institutional size retort pouches still promises some significant advantage over the No. 10 can. The thin profile of the pouch lends itself to shorter heat process time, thus retaining higher quality of the product. There are corrosion and other similar deterioration problems not associated with the pouch that are possible with the can. The institutional size pouch offers significant economical advantages in terms of material, processing, handling and shipping costs, over the No. 10 can. Table 3 summarizes some costs associated with the institutional size pouch and the No. 10 can.

Table 3. Comparison of Major Costs Associated with Production of Food Entrees in Institutional-Size Retort Pouch and No. 10 can.

	POUCH		CAN	
	Beef Stew	Chicken a La King	Beef Stew	Chicken a La King
Food (6.5 lb)	$1.710	$1.430	$1.710	$1.430
Pouch/Can Cost	0.807	0.807	0.804	0.804
Production - Labor - Processing - Equipment	0.944	0.944	1.625	1.625
Shipping Boxes	0.167	0.167	0.167	0.167
TOTAL (per pouch)	$3.628	$3.348	$4.306	$4.026

Note: The above figures are based on estimated costs provided by the subcontractor, Food Innovisions, Inc. These figures have not been verified by Chemac Industries, Inc. Also, no provisions have been made to include cost of freight, overhead or profit.

This document reports research undertaken at the US Army Natick Research, Development and Engineering Center and has been assigned No. NATICK/TR-90/041 in the series of reports approved for publication.

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Appendix A

Product Formulations, Preparation Procedures and Ingredient Suppliers

APPENDIX A

Product Formulations, Preparation Procedures and Ingredient Suppliers

Both, Beef Stew and Chicken A La King, formulations were extracted from the Military Specifications, MIL-B-44059B and MIL-C-44060B,[8,9] respectively.

BEEF STEW (MIL-B-44059B)

Beef logs that had been cooked, frozen then diced as per the Military Specifications were purchased from E. Huttenbauer of Cincinnati, OH. The beef logs were prepared according to the following formulation:

Ingredients	% by Weight
Beef	95.75
Ice or Ice Water	3.00
Salt	1.00
Sodium tripolyphosphate	0.25

The cooked and diced beef was incorporated into the Beef Stew formulation as follows:

Ingredients	% by Weight
Beef, Diced	40.75
Sauce	33.80
Potatoes, Diced	15.00
Carrots, Diced	7.50
Peas	2.95

The sauce was prepared separately according to the following formulation:

BEEF STEW

Ingredients	% by Weight
Water	79.85
Starch, Modified, High Opacity	5.88
Tomato Paste, 30% Solids	5.88
Margarine	4.41
Salt	1.50
Sugar	0.94
Onion Powder	0.59
Vegetable Protein, Hydrolyzed	0.32
Pepper, Black	0.24
Celery, Soluble	0.18
Color, Caramel	0.18
Garlic Powder	0.03

Preparation:

1. With portion of the water, prepare a slurry of starch. Wisk thoroughly to obtain uniform slurry.

2. Adjust tomato paste solids to 30% by adding water, if necessary.

3. In a steam jacketed kettle, melt margarine.

4. Add tomato paste and remaining water to the kettle and mix thoroughly.

5. In a separate container, combine and mix thoroughly all dry ingredients (salt, sugar, onion powder, vegetable protein, pepper, soluble celery, caramel color and garlic powder).

6. Add the dry mix to the kettle, mix thoroughly and bring temperature to 150°F (65.6°C).

7. Add starch slurry that had been previously prepared and bring temperature to 180°F (82.2°C) and hold for 5 minutes.

8. If necessary, add more water to the sauce to compensate for any significant evaporation loss during cooking and holding.

9. Add diced beef, carrots, potatoes and peas to the sauce in the kettle. Agitate the mixture until all ingredients appear to be uniformly distributed in the final product.

At this point, the Beef Stew can either be dispensed into the pouches or refrigerated for later use. If the product is refrigerated then it must be reheated to 130-150°F (55-65°C) prior to dispensing into pouches.

TABLE A1

List of Beef Stew Ingredients and the Respective Suppliers.

Ingredient	Description	Source
Modified Starch	Clear Jel-A	National Starch Co.
Tomato Paste	Hunt's, 26% Solids	Arrow Sysko Food Service Jefferson, LA
Margarine	Vegetable Type	" " "
Salt	Iodized	" " "
Sugar	Granulated	Guercho's Food Distributors Harahan, LA
Onion Powder Black Pepper Garlic Powder	Meet Standards of American Dehydrated Onion & Garlic Association	Spice Delight Inc. Harahan, LA
Hydrolyzed Vegetable Protein	VI-ZATE 115 HVP Powder	A.E. Staley Mfg. Co. Decateur, IL
Celery	Soluble on Dex	Baltimore Spice Co.
Caramel Color		E.M. Carriere & Son New Orleans, LA
Cooked Beef	In conformance to Spec. MIL-044059B	E. Huttenbauer Cincinnati, OH
Potatoes	3/8" diced, fresh	Guercio Food Distrib.
Carrots	Frozen & Diced	Arrow Sysko Food Service Jefferson, LA
Green Peas	Frozen	" " "

CHICKEN A LA KING (MIL-C-44060B)

At the request of the COR, the specification for chicken to be used in this product were amended to use chicken that had been cooked, pulled off the carcass and then passed through a screen to remove pieces smaller than 1/4" (0.6 cm).

Previously cooked chicken was incorporated in the Chicken A La King formulation as follows:

Ingredients	% by Weight
Chicken, Cooked	45.00
Sauce	55.00

The sauce for the Chicken A La King was prepared separately, in accordance with the following formulation:

Ingredients	% by Weight
Chicken Broth, (30-35% Solids)	70.30
Modified Starch, High Opacity	6.00
Chicken Fat	4.72
Mushrooms, Canned, Stems/Pieces	3.67
Peas, Green, Frozen	3.52
Shortening	2.25
Cream Cheese, Dehydrated	2.20
Pimiento	1.78
Onions, Dehydrated	1.77
Brine from Mushrooms	1.70
Salt	0.75
Celery, Dehydrated	0.55
Pepper, Sweet, Dehydrated	0.32
Lecithin	0.32
Pepper, White, Ground	0.10
Bay Leaves, Ground	0.05

Preparation:

1. Adjust chicken broth to correct soluble solids with water.

2. In a pail, combine a portion of chicken broth, starch and powdered vegetable shortening to form a slurry.

3. In a steam jacketed kettle, prepare an emulsion with the remainder of chicken broth, mushroom brine, chicken fat and lecithin.

4. With continuous and vigorous agitation, bring the emulsion to boil. Maintain vigorous agitation to attain maximum emulsification of the fat.

5. To the emulsion, add cream cheese and stir until the cheese is uniformly dispersed.

6. Cool emulsion to 180°F (82.2°C) or lower and, with the exception of chicken, add the remaining ingredients.

7. Before adding to the emulsion, the dehydrated vegetables should be rehydrated in two times their weight of water overnight or until most of the water is absorbed by the vegetables.

8. Add starch slurry, continue mixing and heat to 180-190°F (82.2-87.8°C) and hold for 5 minutes.

9. Add chicken and mix thoroughly.

10. If necessary, add water to make up for any evaporation losses.

At this point the Chicken A La King can be either dispensed into the pouches or refrigerated for later use. If the product is refrigerated then it must be reheated to 130-150°F (55-65°C) prior to dispensing into pouches.

TABLE A2

List of Chicken A La King Ingredients and Respective Suppliers.

Ingredient	Description	Source
Frozen Chicken Broth	Blue Coach 8% SS	Swift-Eckrick Inc. Chicago, IL
Modified Starch	Clear Jel-A	National Starch Co.
Dehydrated Cream Cheese	Chez-Tone	Beatreme Food Ingredients Chicago, IL.
Frozen Chicken		Swift-Eckrick Inc. Chicago, IL.
Mushrooms	Canned, Stems & Pieces	Arrow Sysko Food Service Jefferson, LA.
Green Peas	Frozen	" " "
Pimiento	Dunbar #10 Can Chopped	" " "
Salt	Iodized	" " "
Powdered Shortening	Vegetable Type (NDX-112-V)	Beatreme Food Ingredients Chicago, IL.
Dehydrated Onions	Fancy Chopped	Baltimore Spice Co. Baltimore, MD.
Dehydrated Celery	1/8" - 3/8" cross cut (Code 29-908)	California Veg. Exchange Modesto, CA.
Sweet Green Pepper	Freeze Dried 1-320-0000-820	Armanino Farms Fremont, CA.
Lecithin	Central 3F-UB	Central Soya
White Pepper Bay Leaves	Ground Ground	Spice Delight Harahan, LA.
Mushroom Brine	Drained from Canned Mushrooms	Various
Diced Chicken Meat	1/2" Diced	Loubat L. Frank Co. New Orleans, LA

Appendix B

Determination of Thermal Process

to Attain Commercial Sterility in

Retorted Institutional-Size Pouches

APPENDIX B

Determination of Thermal Process to Attain Commercial Sterility in Retorted Institutional-Size Pouches

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Thermal processes employed for retorting Beef Stew and Chicken A La King were specified to be equivalent to lethality (F_o) $\geq$ - 6 minutes at 250^{o}F (121^{o}C) with z value taken to be 18^{o}F (10C^o). Food Innovisions, Inc. employed a process computer, Log-Tec Retort Controller, Model 9 (Log-Tec, Div. of Central Analytical Laboratories, Inc., Kenner, LA), interfaced directly with the retort, to determine the necessary thermal process. The computer calculated the thermal process by evaluating the time temperature effects off the slowest heating zone of the product in test pouches.

For each retort batch, three pouches were equipped with copper/constantan thermocouples to monitor heating and cooling temperatures of the packaged product. The thermocouple sensing junctions were located in the slowest heating zone of the product in each pouch, namely, the geometric center of the pouch. The pouches equipped with thermocouples were placed in the retort carts, on racks third from the top. The thermocouple leads were guided out of the retort and connected to the computer.

After the come-up time, designated as zero time, which also corresponds to the retort reaching the processing temperature, the process computer begins to monitor time-temperature, the process computer begins to monitor time-temperature pairs from each pouch equipped with the thermocouples. For each time-temperature pair, the process computer computes lethal rate (L), using the Improved General Method and z = 18^{o}F (10C^o), as follows:

$$L = \log^{-1} \left[\frac{T - 250}{z} \right]$$

where T = product temperature, F

Process lethality (F_o) can be defined as the product of lethal rate and the time (in minutes) during which the corresponding temperature is operative. Therefore, addition of interval lethalities (lethal rate X time) over some length of time will yield the process lethality (F_o). During the retort cycle, the process computer continually monitors process lethality. Once the target lethality is achieved, the heating process is terminated.

The filled and sealed pouches were retorted in a Batch Over Pressure Water Retort, Model RSE2, manufactured by Stock America, Inc., Milwaukee, WI. Between 35-40 psi (2.5-2.8 kg/sq. cm) overriding pressure was maintained in the retort during the entire processing and cooling cycles to prevent straining of pouch seals or pouch body. The time, temperature and overpressure of the complete processing and cooling cycle, for each batch, were recorded by instrumentation of the retort control system. Table B1 summarizes the processing parameters for each retort batch.

Table B1

Thermal Process Employed for Each Batch of Beef Stew and Chicken A La King to Attain Target Lethality of Minimum 6.0 minutes.

Batch #	Initial Product Temp. F	Come-up Time	Mercury Thermometer F	Chart Recorder F	Over Pressure psi	Cook Time min.
Beef Stew						
1	80.9	13	254	254	35	49
2	88.4	12	254	252	35	50
3	76.0	12	252	252	35	62
6	110.8	12	252	252	40	53
7	74.0	12	253	253	40	54
12	80.0	12	252	252	35	60
13	80.0	12	254	254	35	60
14	----	12	252	252	35	80
15	----	12	252	252	35	80
16	----	10	254	254	35	80
Chicken A La King						
4	83.0	12	252	252	40	88
5	80.8	9	252	252	40	80
8	117.0	11	253	253	40	60
9	98.0	11	252	252	40	101
10	117.0	11	251	251	35	80
11	117.0	11	254	254	35	80

Appendix C

Results of Vibration and Drop Tests

on Beef Stew Conducted at

Riviana Foods, Inc., Houston, Texas

APPENDIX C

Results of Vibration and Drop Tests on
Beef Stew Conducted at Riviana Foods, Inc.
Houston, Texas

Test Report No. 0007-88 No. of Pages 7

Report of Test on

Vibration and Drop Tests for

Food Innovisions

RVR PACKAGE TESTING CENTER
RIVIANA FOODS INC.
1702 TAYLOR STREET HOUSTON, TEXAS 77007
TEL: 713/881-8221

Date March 21, 1988

	Prepared	Checked	Approved
By	K.Y.Lim	K.Y.Lim	L.C.Braña
Signed			
Date	3/21/88	3/21/88	3/21/88

ADMINISTRATIVE DATA/INFORMATION

1.0 PURPOSE OF TESTS

To determine the ability of the packaging system to protect the product from the hazards of transportation vibration and drop test.

2.0 DESCRIPTION OF TEST MATERIALS

2.1 Product is beef stew, thermostabilized, and packed in 12" x 15" retort pouch, 6 1/2 lb per pouch.

2.2 Shipping container is RSC, V3C; it complies with specs PPP-B-636 and MU PPP-F-320 of latest revision, 19 3/8"L x 12 7/8"W x 5 1/2"D

2.3 Partition is double wall B/C flute, special die cut as shown in diagram #1.

2.4 Pad is double wall B/C flute 9" x 12".

2.5 Total number of samples is five cases each containing six pouches.

2.6 Packing method - two bags side by side lengthwise (divided by partition) one bag end to end widthwise and three layers high depthwise (see diagram 3)

2.7 Container is closed with hot melt adhesive and taped both top and bottom..

3.0 TEST PROCEDURES USED

Ref NSTA Test Procedure Project 1a, modified.

3.1 Vibration at 220 rpm in synchronous motion for 30 min with 90 degree turn at 50% vibration.

3.2 Drop test at 18" in the following sequence: (the numbering of container faces are shown in diagram #2)

3.2.1 Corner 2-3-5
3.2.2 Edge 3-5
3.2.3 ~~Side~~ 5 End
3.2.4 Side 2
3.2.5 Bottom 3

4.0 DATE TEST COMPLETED: March 21, 1988

5.0 TEST CONDUCTED BY: RVR Package Testing Center
1702 Taylor Street
Houston, Texas 77007

6.0 DISPOSITION OF TEST MATERIALS:

Product to be returned pending further instruction.

Report No. 0007-88 Page 2

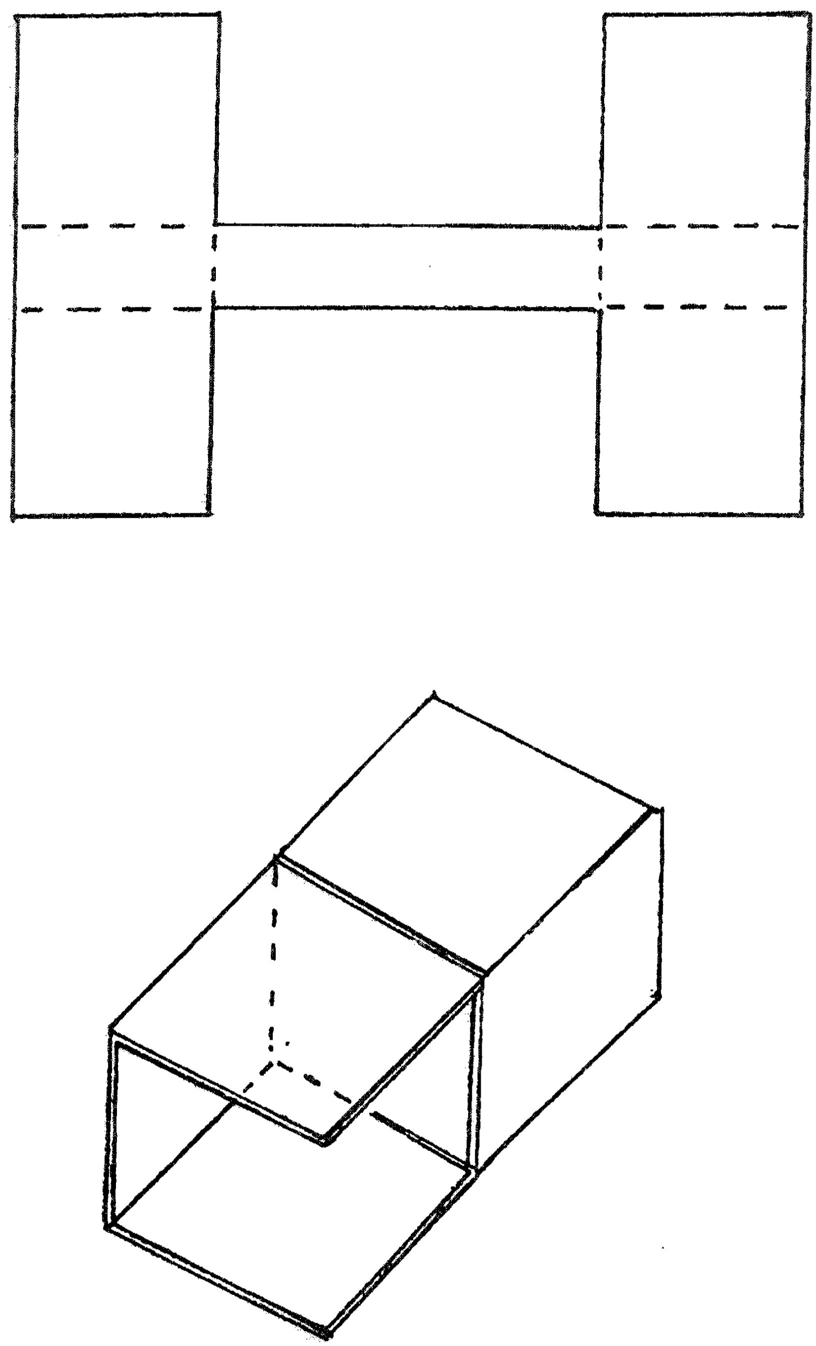

Figure C1. The Die-Cut Insert of the Institutional Size Pouch Shipping Container

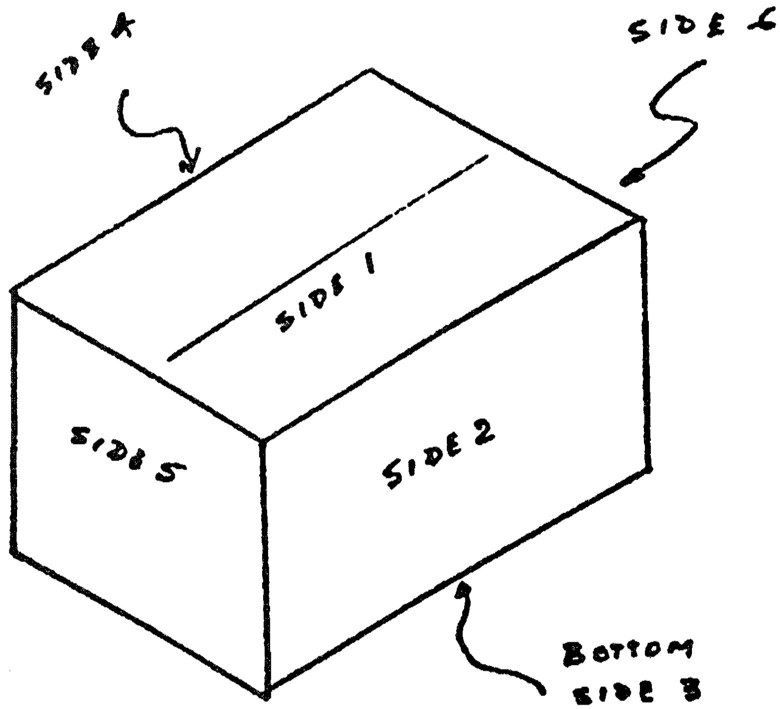

Figure C2. Institutional Size Pouch Shipping Container

7.0 TEST RESULTS

Case #	# Wt.	Pouch Failure (leak) Yes/No	Top Partition Glued to Flap Yes/No	Sufficient Padding Yes/No	Remarks
1	42 1/2	No	No	No needs 2 pads	3 pouches each marked #1 & #2. The edgedrop (side 5) is the pouch marked #1.
2	42 1/2	No	Yes	No - Side 5 needs 2 pads Side 6 needs 3 pads	All pouches marked #1
3	42 1/2	No	Yes	No needs 2 pads	All pouches marked #1
4	42 1/2	No	Yes	Yes	All pouches marked #1 Tape broke on fourth drop at bottom of case
5	42 1/2	No	Yes	No needs 2 pads	All pouches marked #1

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Fort Lee, VA 23807

Commandant
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